

U.S. FISH AND WILDLIFE SERVICE  
NEW ENGLAND FIELD OFFICE  
SPECIAL REPORT FY08-NEFO-1-EC

**Contaminant Sampling to Facilitate Dam  
Removals/Habitat Restoration in New England**



June 2008

Contaminant Sampling to Facilitate Dam  
Removals/Habitat Restoration in New England

FY08-NEFO-1-EC

Regional ID: 5F39  
DEQ ID: 20035004

Prepared By:

Andrew R. Major and John P. Warner  
U.S. Fish and Wildlife Service  
New England Field Office

June 2008

**Suggested citation:** Major A.R. and J.P. Warner. 2008. Contaminant sampling to facilitate dam removals/habitat restoration in New England. USFWS Special Report FY-NEFO-1-EC. New England Field Office, Concord, NH. 22 pp.

## Table of Contents

LIST OF TABLES.....	4
LIST OF FIGURES .....	4
APPENDICES .....	4
LIST OF ACRONIMS/ABBREVIATIONS .....	5
1.0 Abstract.....	6
2.0 Introduction.....	6
3.0 Methods and Materials.....	7
4.0 Results.....	8
4.1 MASSACHUSETTS.....	8
4.2 NEW HAMPSHIRE .....	9
4.3 Rhode Island .....	9
4.4 VERMONT.....	10
5.0 Discussion and Management Recommendations .....	11
6.0 Acknowledgements.....	12
7.0 Literature Cited.....	12

## **LIST OF TABLES**

Table 1. Summary results for the nine sites sampled as part of this study	8
---	---

## **LIST OF FIGURES**

Figure 1. Eel River Bog and Sampling Locations	14
Figure 2. Eel River Dam and Sampling Locations	15
Figure 3. Merrimack Village Dam and Sampling Locations	16
Figure 4. Kenyon Dam and Sampling Locations	17
Figure 5. Lower Shannock Dam and Sampling Locations	18
Figure 6. Dufresne Pond Dam and Sampling Locations	19
Figure 7. East Burke Dam and Sampling Locations	20
Figure 8. Island Corps Dam and Sampling Locations	21
Figure 9. Lower Eaton Dam and Sampling Locations	22

## **APPENDICES**

Appendix I. USFWS STANDARD OPERATING PROCEDURES (SOPs) FOR SEDIMENT SAMPLING BEHIND DAMS	
Appendix II. Contaminant Levels in Sediments at the Eel River Bog, MA	
Appendix III. Contaminant Levels in Sediments at the Eel River Dam, MA	
Appendix IV. Contaminant Levels in Sediments at the Merrimack Village Dam, NH	
Appendix V. Contaminant Levels in Sediments at the Kenyon Dam, RI	
Appendix VI. Contaminant Levels in Sediments at the Lower Shannock Dam, RI	
Appendix VII. Contaminant Levels in Sediments at the Dufresne Pond Dam, VT	
Appendix VIII. Contaminant Levels in Sediments at the East Burke Dam, VT	
Appendix IX. Contaminant Levels in Sediments at the Island Corps Dam, VT	
Appendix X. Contaminant Levels in Sediments at the Lower Eaton Dam, VT	

## LIST OF ACRONIMS/ABBREVIATIONS

ACF	Analytical Control Facility
BHC	benzenehexachloride
DDD	dichlorodiphenyldicloroethane
DDE	dichlorodiphenyldicloroethylene
DDT	dichlorodiphenyltrichloroethane
DEQ	Division of Environmental Quality (USFWS)
HCB	hexachlorobenzene
mg/kg	milligrams per kilogram (or parts-per-million)
ug/kg	micrograms per kilogram (or parts-per-billion)
OC	organochlorine
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	probable effect concentration
PEL	probable effects level
ppb	parts-per-billion
ppm	parts-per-million
QA/QC	quality assurance/quality control
SOP	standard operating procedure
TEC	threshold effect concentration
TEL	threshold effect level
USFWS	U.S. Fish and Wildlife Service
Zn	zinc

## **1.0 Abstract**

In a screening level survey of sediments impounded by New England dams that were being investigated for possible removal, only one of nine sites had contaminant levels below threshold effect levels for metals, organochlorines, and polynuclear aromatic hydrocarbons. One additional site had levels that exceeded threshold effect levels, but did not exceed probable effect levels. The remaining seven sites exceeded probable effect levels in at least one of the three contaminant groups. It is important to conduct contaminant testing early in the process so that any sediment abatement measures can be factored into the total cost of the project.

Keywords: New England, impoundment, dam, contaminants, sediment, metals, organochlorines, polynuclear aromatic hydrocarbons, Regional ID: 5F39, DEQ ID: 20035004, Congressional Districts: MA (9), New Hampshire (1), Rhode Island (2), Vermont (1).

## **2.0 Introduction**

It is well documented that dams significantly change the physical, chemical, and biological properties of riverine ecosystems (Baxter 1977, Devine 1995, Ligon et al. 1995, Chatterjee 1997). Awareness of the ecological costs of impounded rivers combined with the diminished economic returns/liabilities of these aging structures has made dam removal a viable management option. Post-removal studies have demonstrated the positive environmental benefits of dam removal (Hill et al. 1993, Dadswell 1996). These results can occur quite quickly. Stanley and Luebke (2002) reported that within one year of dam removal, macroinvertebrate assemblages in formally impounded reaches did not significantly differ from those in either the upstream reference site or in other unimpounded reaches below the dam site.

Recognizing the opportunity to restore anadromous fish and endangered freshwater mussel habitats, the New England Field Office participates on a number of state task forces examining individual dams for possible removal. The dams in New England being considered for removal are associated with known 19th and 20th century industrial sites, with the potential for the impounded sediments to contain contaminant levels high enough to pose a risk to aquatic life during the re-mobilization of sediments following dam removal. The state of Connecticut experienced this problem when one of its dam removal projects resulted in contamination of downstream surficial sediments after a dam was removed (Rick Jacobson, Connecticut Department of Environmental Protection, personal communication). Because of this concern, a contaminant survey of impounded sediments is normally required on all dams prior to removal. This requirement has been problematic. Although funds exist for removal actions, it has been difficult to obtain funds for pre-removal assessment activities, with resultant delays of up to two years. Our objective was to conduct a screening level environmental contaminant assessment of impounded sediments from nine dams in New England targeted for potential removal to ensure that contaminant levels were below thresholds that would harm aquatic life.

### 3.0 Methods and Materials

Site selection was accomplished by consulting the various federal, state, and non-governmental agencies involved with dam removal activities in New England. These organizations have conducted technical and political assessments to determine the most feasible removal projects. Sites were selected based on owner interest, engineering constraints, projected cost, and overall resource benefits.

A Standard Operating Procedure (Appendix I) was developed to guide sample collection. Five sampling points were selected based on the SOP criteria.<sup>1</sup> Samples were taken using an Ekman, Ponar, or Wildco stainless steel corer, depending on the sediment conditions. All samples were analyzed using USFWS ACF approved QA/QC methodologies and laboratories. Analytes included Total Organic Carbon (TOC), grain size analysis, percent moisture, a metals scan, an organochlorine (OC) scan, and a polynuclear aromatic hydrocarbon (PAH) scan.<sup>2</sup> The analytical results were compared to two different sediment quality guidelines (Buchman 1999 and MacDonald et al. 2000) to determine risk to aquatic biota. The two threshold effect levels were the Threshold Effect Concentration (TEC) and the Threshold Effects Level (TEL), and the two probable effect levels were the Probable Effect Concentration (PEC) and the Probable Effects Level (PEL)

---

<sup>1</sup> There were five deviations from the SOP. At three sites (Merrimack Village Dam, Kenyon Dam, and Lower Shannock Dam), the first sample was not taken below the dam due to safety/access issues. At Eel River Dam, only 4 sediment samples were collected due to the small size of the impoundment. At East Burke Dam, the sample numbers were inadvertently reversed with sample #5 collected below the dam and sample #1 collected at the head of the impoundment.

<sup>2</sup> Because of the agricultural history of the site, an organophosphate/carbamate scan was included for the Eel River Bog sediments.

## 4.0 Results

### Summary

At only one of nine sites (East Burke) did we document no exceedence of the selected sediment quality guidelines. At one additional site (Merrimack Village), threshold levels were reached, but probable effect levels were not. At all of the other sites, probable effect levels were reached in at least one of the contaminant groups (Table 1).

Table 1. Summary results for the nine sites sampled as part of this study. **Y** denotes that at least one of the samples exceeded the sediment quality guidelines.

Site	Metals		Organochlorines		PAHs	
	TEC/TEL	PEC/PEL	TEC/TEL	PEC/PEL	TEC/TEL	PEC/PEL
<b>Massachusetts</b>						
Eel River Bog	N	N	Y	Y	N	N
Eel River Dam	Y	N	Y	Y	Y	Y
<b>New Hampshire</b>						
Merrimack Village	N	N	Y	N	Y	N
<b>Rhode Island</b>						
Kenyon	Y	N	Y	N	Y	Y
Lower Shannock	Y	N	Y	N	Y	Y
<b>Vermont</b>						
Dufresne Pond	Y	Y	N	N	Y	N
East Burke	N	N	N	N	N	N
Island Corp	Y	N	N	N	Y	Y
Lower Eaton	Y	Y	N	N	Y	N

### 4.1 MASSACHUSETTS

**Eel River Bog** (Figure 1, Appendix II)

**Waterbody:** Eel River

**Date Sampled:** 09/25/06

**Metals:** All results were below threshold effect levels.

**Organics:** Total DDE, Total DDT, and endrin sediment levels exceeded threshold effect levels in at least one sample. Total DDD, p,p-DDE, and dieldrin sediment levels exceeded probable effect levels in at least one sample.

**PAHs:** All results were below threshold effect levels.

**Organophosphates/carbamates:** All results were below threshold effect levels.

**Eel River Dam** (Figure 2, Appendix III)

**Waterbody:** Eel River

**Date Sampled:** 09/25/06

**Metals:** Arsenic, cadmium, and lead sediment levels exceeded threshold effect levels in at least one sample.

**Organics:** Total PCB sediment levels exceeded threshold effect levels in at least one sample. P,p-DDD, Total DDD, p,p-DDE, Total DDE, p,p-DDT, Total DDT, and dieldrin sediment levels exceeded probable effect levels in at least one sample.

**PAHs:** Anthracene, fluoranthene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenz[a,h]anthracene, and Total PAH sediment levels exceeded threshold effect levels in at least one sample. Phenanthrene and pyrene sediment levels exceeded probable effect levels in at least one sample.

## **4.2 NEW HAMPSHIRE**

**Merrimack Village Dam** (Figure 3, Appendix IV)

**Waterbody:** Souhegan River

**Date Sampled:** 10/10/03

**Metals:** All results were below threshold effect levels.

**Organics:** Total PCB sediment levels exceeded threshold effect levels in at least one sample.

**PAHs:** Pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, and Total PAH sediment levels exceeded threshold effect levels in at least one sample.

## **4.3 Rhode Island**

**Kenyon Dam** (Figure 4, Appendix V)

**Waterbody:** Pawcatuck River

**Date Sampled:** 08/17/06

**Metals:** Cadmium and lead sediment levels exceeded threshold effect levels in at least one sample.

**Organics:** Total DDD, p,p-DDE, Total DDE, and Total PCB sediment levels exceeded threshold effect levels in at least one sample.

**PAHs:** Anthracene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[a]pyrene, dibenz[a,h]anthracene, and Total PAH sediment levels exceeded threshold effect levels in at least one sample. Phenanthrene sediment levels exceeded probable effect levels in at least one sample.

**Lower Shannock Dam** (Figure 5, Appendix VI)

**Waterbody:** Pawcatuck River

**Date Sampled:** 10/12/04

**Metals:** Cadmium chromium, lead, and mercury sediment levels exceeded threshold effect levels in at least one sample.

**Organics:** P,p-DDD, Total DDD, and Total DDE sediment levels exceeded threshold effect levels in at least one sample. Total PCB sediment levels exceeded probable effect levels in at least one sample.

**PAHs:** Anthracene, benzo[b]fluoranthene, and dibenz[a,h]anthracene sediment levels exceeded threshold effect levels in at least one sample. Naphthalene, fluorine, phenanthrene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[a]pyrene, and Total PAH sediment levels exceeded probable effect levels in at least one sample.

#### **4.4 VERMONT**

**Dufresne Pond Dam** (Figure 6, Appendix VII)

**Waterbody:** Batten Kill River

**Date Sampled:** 09/07/05

**Metals:** Cadmium, nickel, and zinc sediment levels exceeded threshold effect levels in at least one sample. Mercury sediment levels exceeded probable effect levels in at least one sample.

**Organics:** All results were below threshold effect levels.

**PAHs:** Phenanthrene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, and benzo[a]pyrene exceeded threshold effect levels in at least one sample.

**East Burke Dam** (Figure 7, Appendix VIII)

**Waterbody:** East Branch of the Passumpsic River

**Date Sampled:** 05/13/04

**Metals:** All results were below threshold effect levels.

**Organics:** All results were below threshold effect levels.

**PAHs:** All results were below threshold effect levels.

**Island Corp Dam** (Figure 8, Appendix IX)

**Waterbody:** Saxtons River

**Date Sampled:** 09/29/04

**Metals:** All results were below threshold effect levels.

**Organics:** All results were below threshold effect levels.

**PAHs:** Phenanthrene, anthracene, chrysene, benzo[b]fluoranthene, benzo[a]pyrene, and dibenz[a,h]anthracene sediment levels exceeded threshold effect levels in at least one sample. Pyrene and benz[a]anthracene sediment levels exceeded probable effect levels in at least one sample.

**Lower Eaton Dam** (Figure 9, Appendix X)

**Waterbody:** First Branch, White River      **Date Sampled:** 10/12/04

**Metals:** Cadmium and nickel sediment levels exceeded threshold effect levels in at least one sample. Copper sediment levels exceeded probable effect levels in at least one sample.

**Organics:** All results were below threshold effect levels.

**PAHs:** Phenanthrene, pyrene, benz[a]anthracene, benzo[b]fluoranthene, and benzo[a]pyrene sediment levels exceeded threshold effect levels in at least one sample.

## 5.0 Discussion and Management Recommendations

One of the most important points to make about this study is to point out what it does not do. It was never our intention to conduct sampling in such a way as to fully characterize the extent of contamination at any one site. Our methods were selected to provide a **screening** level assessment of contaminant levels in surficial sediments. This study does not, and can not, answer questions such as how extensive is the contamination, how deep are the sediments contaminated, or are levels high enough to impact aquatic life if the sediments are allowed to be transported downstream? Our intent was that any exceedence of sediment quality criteria would trigger additional sampling at the individual sites to answer these more specific questions. We readily admit that threshold effect values are quite conservative in their prediction of risk to aquatic life, and that site-specific variables determine whether a contaminant will be bioavailable. An example of this process took place at the Merrimack Village Dam. PAH and PCB exceedence of threshold effect levels triggered additional sediment collection for toxicity testing. A 10-day survival and growth test using the freshwater amphipod *Hyaella azteca* was performed using sediment collected from two sites in the impoundment. Mean survival rates were 86% and 94% as compared to the lab control of 88%. Growth rates were slightly higher as compared to the control organisms (Gomez and Sullivan 2004). Based on these results, the issue of sediment toxicity was resolved and the project moved forward. The project timeline anticipates that removal of this dam will occur during low flow conditions in the summer of 2008.

Since dams act as effective barriers to sediment transport in river systems, we anticipated that we would find contaminated sediments at the majority of our sites. Our results confirm this not unexpected result, but they also reinforce the need to test for contaminants at each site where dam removal is being considered so as to preclude

inadvertently spreading the contaminated sediment downstream. There are times when a barrier to sediment transport has protected downstream habitat. A detailed review of the data from the Eel River Dam (Appendix III) reveals that while sediment samples from the impoundment had levels of DDT and its metabolites well above the probable effect levels, the downstream sample had only one constituent (p,p-DDE) above the threshold effect levels. Projects where sediment contaminant levels are elevated do not preclude removal of dam structures, but they do necessitate consideration of sediment abatement measures as part of the project planning process to accurately reflect the total cost of dam removal.

## **6.0 Acknowledgements**

We would like to thank the USFWS, Division of Environmental Quality for funding this project, Dr. Tim Fannin, Regional EC Coordinator for his assistance and encouragement, and biologists Tony Tur and Eric Derleth for assistance with sample collection.

## **7.0 Literature Cited**

- Baxter, R.M. 1977. Environmental effects of dams and impoundments. *Annual review Of Ecology and Systematics* 8:255-283.
- Buchman, M.F., 1999, NOAA Screening Quick Reference Tables, NOAA HAZMAT report 99-1, Seattle, WA. Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12p.
- Chatterjee, P. 1997. Dam Busting. *New Scientist*. Pg. 34-37.
- Csuros M. 1994. Environmental sampling and analysis for technicians. CRC Press. 320pp.
- Dadswell, M.J. 1996. The removal of Edwards Dam, Kennebec River, Maine: Its effects on the restoration of anadromous fishes. Draft Environmental Impact Statement, Kennebec River, Maine, Appendices 1-3.
- Devine, R.S. 1995. The Trouble with Dams. *The Atlantic Monthly*. August: 64-74.
- Gomez and Sullivan. 2004. Merrimack Village Dam Final Report: Phase I – Dam Removal Feasibility Study. Prepared for Pennichuck Water Works, 25 Manchester Street, Merrimack NH 03054
- Hill, M.J., E.A. Long, and S. Harding. 1993. Effects of dam removal on Dead Lake, Chipola River, Florida. *Apalachicola River Watershed Investigations*, Florida Game and Fresh Water Fish Commission. A Wallop-Breaux Project F-39-R. 12 pp.

- Ligon, F.K., W.E. Dietrich, and W.J. Trush. 1995. Downstream ecological effects of dams. *Bioscience* 45(3):183-192.
- MacDonald D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.* 39:20-31.
- Stanley, E.H. and M.A. Lubebke. 2002. Short-term changes in channel form and macro-invertebrate communities following low-head dam removal. *J. N. Am. Benthol. Soc.*, 21(1):172-187.

Figure 1. Eel River Bog and Sampling Locations



Figure 2. Eel River Dam and Sampling Locations



Figure 3. Merrimack Village Dam and Sampling Locations

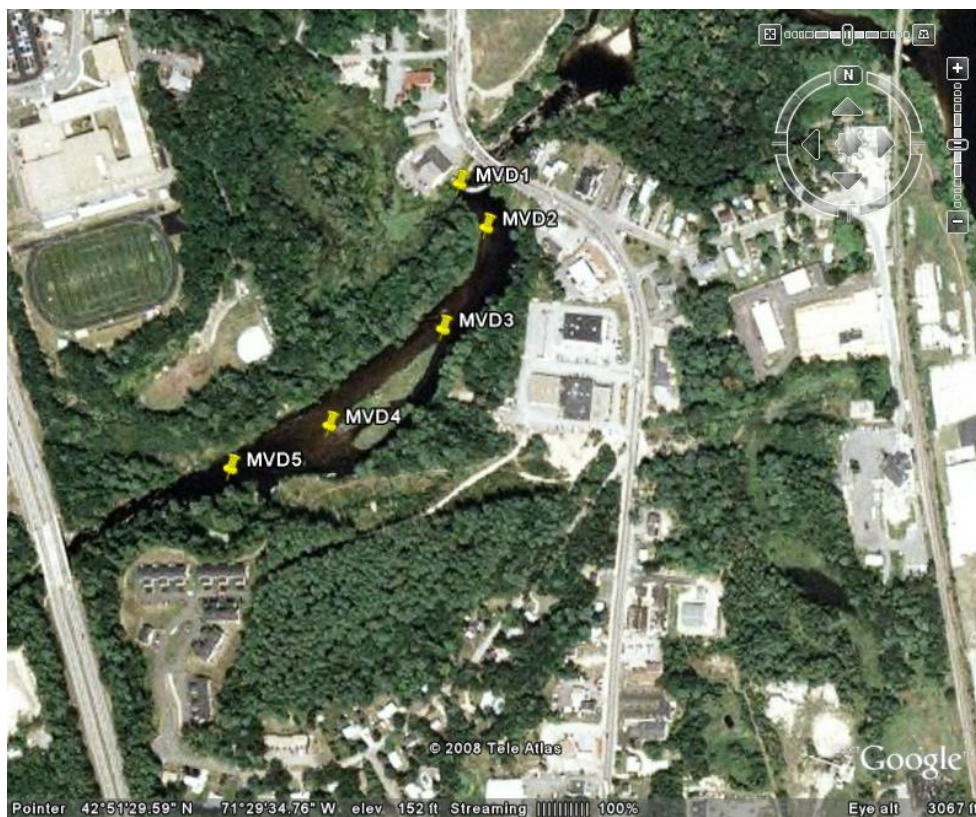


Figure 4. Kenyon Dam and Sampling Locations

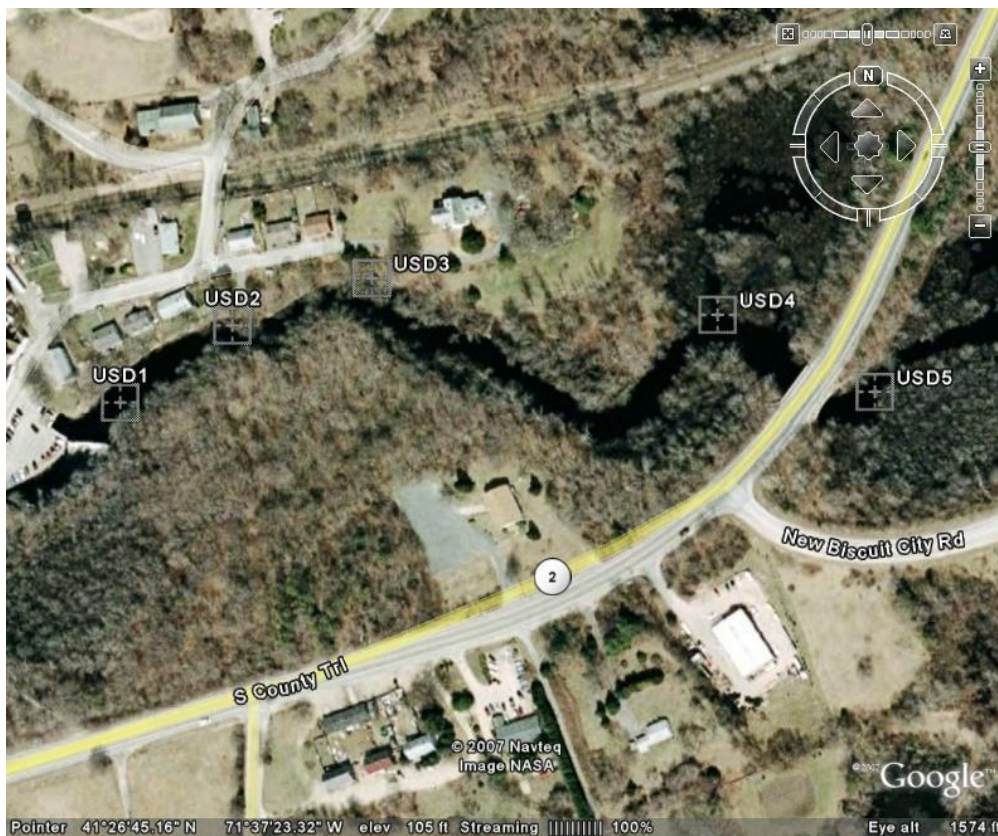


Figure 5. Lower Shannock Dam and Sampling Locations



Figure 6. Dufresne Pond Dam and Sampling Locations



Figure 7. East Burke Dam and Sampling Locations

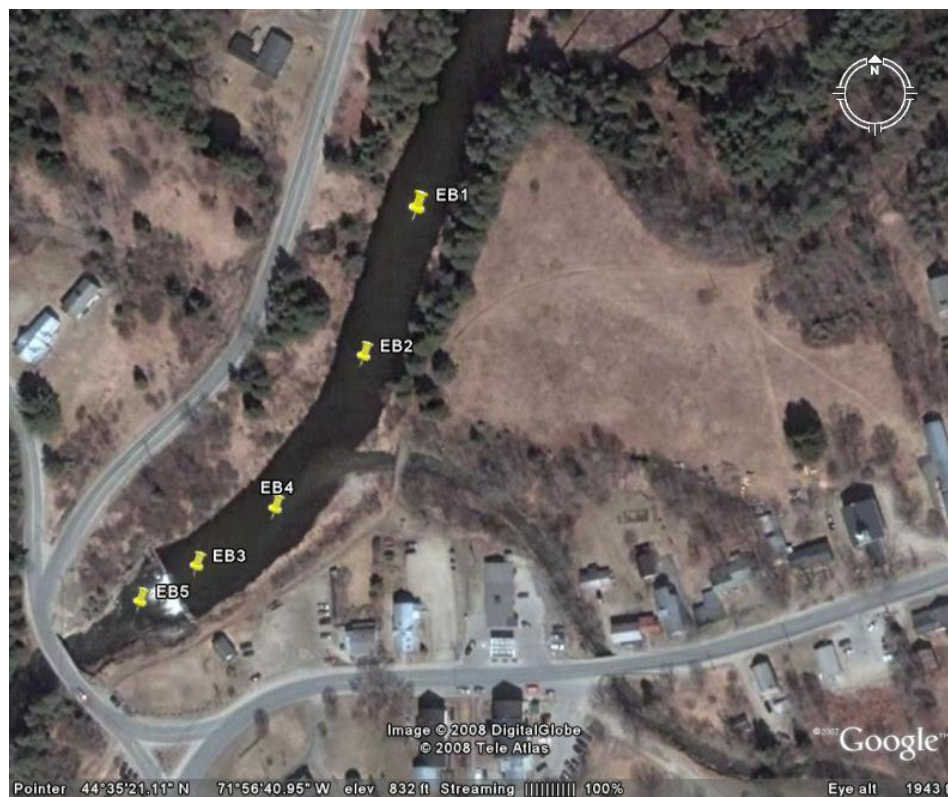


Figure 8. Island Corps Dam and Sampling Locations



Figure 9. Lower Eaton Dam and Sampling Locations

